AMENDMENTS TO THE SPECIFICATION:

Please replace paragraph 1, line 5, on Page 16 with amended paragraph as follows.

FIGURE 6 is a flow chart of the preferred embodiment of the present invention as performed in the digital signal processor during the cycles ~~show~~ shown in FIGURE 2A;

Please replace paragraph 2, line 6, on Page 26 with amended paragraph as follows.

With reference to FIGURES 2 and 2A, and with further reference to FIGURE 3A and FIGURE 6, the cycling as applied to the current-squared calculation is described. FIGURE 3A illustrates current waveform 34 extending between first event signal T_1 and second event signal T_2. Event signals T_1, T_2 are ~~are~~ suitably generated by a circuit controlled by waveform 34. In FIGURE 3A, the circuit generates event signal T_1 responsive to onset of the rising edge of current pulse 140, and the circuit generates event signal T_2 responsive to onset of the rising edge of current pulse 142. Thus, there is a current pulse between each two successive event signals T. Rather than detecting the rising edge, the event signals can instead be generated by detecting another characteristic of the pulse, such as the falling edge of the current pulse.

Please replace paragraph 2, line 16, on Page 27 with amended paragraph as follows.

With continuing reference to FIGURE 5 and with further reference to FIGURE 5A, the polarity of waveform **34** along with an auxiliary "Misc2" signal are input to state machine **170** through"OR" gate ~~**174**~~ **179**. This arrangement enables the FPGA to generate event signals T for pulse welding and for a.c. welding. In the case of a.c. welding, Misc2 is set to zero so that the polarity signal feeds through to cycle counter state machine **170**. For pulse welding, Misc2 is set to one when the arc is shorted, and zero when the arc is not shorted. FIGURE 5A shows a graph of pulse current **180** and the value of Misc2 **182** when pulse welding is used instead of A.C. welding.

Please replace paragraph 2, line 19, Page 16 with amended paragraph as

follows.

FIGURES 17-23 disclose the use of the present invention for an A.C. pulse welding operation, wherein the heat of the A.C. pulse welding operation is controlled by changing certain aspects of waveform **400,** best show in FIGURES 18, 19. Referring now to FIGURE 17, Power Wave power source **14** produces a waveform across electrode **24** and workpiece **26** through choke **22**. A voltage in line ~~**50**~~ 210a is created across the arc to provide a real time representation of the arc voltage. In a like manner, shunt **44** produces a voltage in line **42** which is the instantaneous arc current. As previously described, waveform generator **32** has an output represented by lead **34** to control the duty cycle of the pulse width modulator **36.** The modulator is normally preformed by software and has a pulse rate established by oscillator **36a**. Of course, a hardwired pulse width modulator is sometimes employed. The digital or analog voltage on line **38** determines the wave shape of the welding operation waveform performed by the power source. A Power Wave sold by The Lincoln Electric Company of Cleveland, Ohio is the illustrated, preferred power source. This unit is disclosed generally in Blankenship 5,278,390. The waveform created by generator **32** has a shape controlled by wave shaper **210** so the output voltage, digital or analog, on line **210a** determines the signal in line **34** that generates the specific current waveform at the welding operation. As so far described, the technology is explained above and is well known in the art. In accordance with of the invention, digital comparator **220,** having an output **222** compares the real time power factor signal represented by the value in line **220a** with the desired heat to be created as represented by the digital or analog voltage at line **224**. Thus, output voltage in line **222** is the voltage indicating the relationship between the real time power factor and the desired heat, which is represented as the desired power factor in line **224**. In accordance with the invention, an adjusting circuit **220b** provides a signal in line **222a** that is responsible to the different signal in line **222**. Thus, as the signal in line **222** varies, the output voltage in line **222a** modifies the wave shape in wave shaper **210** to change the shape of the waveform. This action obtains the desired heat as referenced by the manually adjusted voltage in line **224**. The block diagrams shown in FIGURE 17 are performed digitally by controller software using standard DPS to perform waveform technology control of the electric arc welder. The voltage on line **222a** modifies the A.C. pulse waveform structured by wave shaper **210** to maintain the desired heat based upon a relationship with the real time power factor. To accomplish this objective, various aspects of waveform **400** are adjusted by circuit

220b.

Please replace paragraph 1, line 5, on Page 35 with amended paragraph as follows.

To illustrate various portions of the waveform which are adjusted to control heat, waveform **400** is shown schematically in FIGURES 18 and 19. Waveform **400** comprises one of a succession of A.C. pulses including a positive pulse segment **402** and a negative pulse segment **404**. In the preferred embodiment, positive pulse segment **402** is constructed with a peak current portion **410** and a background portion **412** <u>(V_a background portion 430)</u>. The magnitude of the peak current is represented as level **418**. As shown in FIGURE 19, heat adjustment of waveform **400** is accomplished by changing peak level **418**, shown as dashed lines **402a** and represented by **c**. Adjustment of the magnitude of the peak current is one implementation of the invention, where the shape of the waveform is modified to control heat, based upon the real time power factor of the welder. Height **414** of background current portion **412** is indicated as adjustable by dashed lines **414a**. In a like manner, leading edge **416** is adjustable to change the heat of the welding operation as indicated by dashed line **416a**. Magnitude change **a** of the background current and the change **b** in the width of background current are the primary adjustments implemented to cause waveform **400** to create the desired welding heat, while maintaining I_{rms} constant. The primary aspect of the invention for modifying peak current portion **410** is adjustment of peak current magnitude as indicated by **c** as the distance between line **402a and line** 402. However, peak portion **410** normally has a leading ramp **420** and a trailing ramp **422** as shown in the second occurrence of waveform **400**. These two ramps are adjustable to change the heat at the welding operation under the control of the real time power factor. As illustrated in FIGURE 19, the dimensions **a, b**, and **c** as well as the angles of the ramps indicated by **d,** are adjustable to control heat. Circuits to accomplish these adjustments are illustrated in FIGURES 20-23. In these figures, digital circuit **220b** controls the wave shaper **210** by the voltage in line **222a**. FIGURE 20 illustrates the use of circuit **220b** to adjust dimension **a**. Dimension **b** is adjusted by the circuit shown in FIGURE 21. Using the circuits shown in FIGURES 20 and 21 the magnitude of the background current in portion **412** is varied so that the power factor signal at line **220a** is compared with the desired heat represented as a voltage on line **224** to change the background

current. Thus, the background current is adjusted to maintain the desired heat caused by the waveform **400**. The circuits in FIGURES 22 and 23 implement adjustments of the dimensions **c, d**. This changes the magnitude of the peak current or the angle of one or both ramps **220, 222**. In this manner, the peak current portion of waveform **400** is adjusted to create the desired heat. Other aspects of the waveform are adjustable to control the desired heat based upon the real time power factor of the welding operation using a circuit as shown in FIGURES 20-23.

Please replace paragraph 1, line 17, on Page 36 with amended paragraph as follows.

The present invention is added to the system so far described in FIGURES 1-23 and utilizes circuits of the type generally shown in FIGURES 14-16 for adjusting the waveform of the waveform generator in accordance with parameters developed during the welding operation. The general system using the invention is illustrated in FIGURE 24 disclosing the algorithm for a submerged arc control of the type to which the present invention is particularly adapted. Operating system **~~200~~** <u>**300**</u> includes an "arc object", which is the layer of the algorithm that is controlled by the operator. The normal current and wire feed speed is loaded in weld tables in the arc logic library **~~300~~** <u>**310**</u>. Then, depending upon which mode of welding is selected, variables are transferred to the controller for the global scale factor (**GSF**) used in the circuits of FIGURES 14 and 15. These circuits adjust the waveform desired in the welding operation. If a constant voltage mode is selected, the variable is the current for controlling the waveform generator. This is the preferred implementation of the present invention. The wire feed speed is used to control a constant current mode of operation. If multiple machines are connected in parallel the arc object layer determines what should be outputted from each machine to achieve the desired weld. This structure is described in Houston 6,472,634 incorporated by reference herein. Consequently, the arc object is a library for selecting the parameters or variables of operating system **300.** This arc object library is general purpose and can operate system **300** in a manner different than the proposed invention. Arc object library **310** receives information from wire feeder **312.** The nominal wire feed speed is determined by the table of arc object library selected to be processed. The weld control signal from weld control **314** informs the wire feeder of the sequencer state in which the system is operating, as well as the target output voltage.

The system uses a proportional control for constant current welding. Such system is used in a Power Wave welder as disclosed in Blankenship 5,278,390. Wire feeder **312** adds an offset to the normal wire feed speed adjusted in the manner disclosed in FIGURE 16. The feeder adds an offset to the nominal **WFS** based on the desired voltage and actual rms voltage computed in the digital signal processor (**DSP**) of the welder controlled by the system shown in FIGURE 24. The wire feeder does not form a part of the present invention. However, weld control **314** receives information from the arc object library and operates the weld sequencer and sets up waveform generator variables based upon an operator setting of library **310.** Thus, weld control **314** selects the variables used to control the waveform generator by a set of slow loops ~~20~~ 320, identified as a **Wave** 4 loop ~~22~~ 322 and a GSF loop ~~24~~ 324. Information on line **316** to weld control **314** controls the information, as shown in FIGURES 14-16. The output digital filters of these figures adjust the waveform of the waveform generator to control the error signal directed to the filters. Loops ~~22, 24~~ 322,324 are operated fairly slowly in a time sense to control the waveform outputted by waveform generator **340** having a first input **342** which is the work point from the arc object library **310.** Waveform generator **340** produces a waveform controlled by current or power in accordance with the technology so far explained. However, when using the present invention, the waveform generator controls the shape of the waveform to provide a voltage with a slope, as shown in FIGURES 25, 28 and 29. Various sine wave and pulse wave can be constructed using the waveform generator, as taught in Blankenship 5,278,390. However, the invention involves using the waveform generator to produce a voltage with a slope to mimic the dynamic operation of transformer based power sources identified as DC 1000 and AC 1200 sold by The Lincoln Electric Company of Cleveland, Ohio. First loop ~~22~~ 322 adjusts the peak portion of the wave shape to maintain the desired rms current. This is shown in the lower view of FIGURE 16. In practice, filter **336** is a PI type filter with an additional pole to cut off the higher frequencies. The normal outer loop of operating system **300** is set to adjust the **Wave 4** loop to maintain rms current based upon the workpoint in line **342.** GSF loop **324** adjusts either the current or the wire feed speed to maintain the desired rms voltage as shown in the upper view of FIGURE 16. The slow loops **322**, **324** control the waveform generator to change the wave shape in a manner to correct the error from these two feedback loops. Loop ~~24~~ 324 has an output line **324a** to adjust the wire feed speed and communicate with library ~~10~~ 310. This is illustrated in the upper view of FIGURE 16. As so far

explained, waveform generator **340** receives feedback error information in lines **344** and 346 to control the waveform outputted from the generator on line **350.** As disclosed in Houston 6,472,634, input **348** sets the phase of the generator and the plurality of the output waveform directed through line **350** to digital signal processor **360.** The present invention is performed in DSP ~~60~~ 360 that receives arc current in line **362** and arc voltage in line **364.** A kill signal ~~66~~ 366 is directed to the digital signal processor to indicate that the inverter should discontinue operation to reduce the current across the various switches of the inverter awaiting a READY signal. When the switches are all below a preselected value as taught in Stava 6,111,216, a READY signal is generated in line **368.** This signal, from various parallel power sources, is employed to coordinate switching of parallel power sources. The waveform in line **350** is controlled by operating system **300** with the use of slow loops ~~20~~ 320, together with an outer loop including wire feeder. The present invention is performed in DSP **360** so that the waveform generator output in line **350** is modified to produce a digital control signal in line **370** directed to the digital to analog converter **380** for controlling the inverter of the welder. The invention will now be explained as it is performed in the DSP, which receives a KILL signal and then issues a READY signal when the current is reduced to a level for low current polarity switching. The DSP includes the circuit illustrated in FIGURE 26 to perform the present invention to create a signal in line **370** to achieve the output requested by waveform generator **340.** Converter **380** translates the digital signal back into an analog signal used to control the output of the inverter or welder.

Please replace paragraph 1, line 15, on Page 43 with amended paragraph as follows.

The basic program or algorithm in DSP **360** is shown in FIGURES 30, 31 where program ~~80~~ 380 processes the error 1 signal on line **468.** In accordance with the preferred embodiment, the program merely controls the digital converter **360** as shown in FIGURE 26; however, to combine the minimum and maximum current limits on curve **450** the program **600** is employed instead of the direct control as shown in FIGURE 26. By using program **600** in the DSP, the error signal (ERROR 1) in line 26 is calculated or otherwise determined. Then, the minimum and maximum current errors (ERROR 2, ERROR 3) by a digital circuit are calculated, as schematically represented in analog format in FIGURE 31. Comparators **610**, **612** have inputs from the minimum current on

line **454**, the maximum current on line **456** and the actual arc current on line **364.** Comparator **610** determines the relationship of the actual current to the minimum current. This is then directed to a detector circuit **620.** If the current is less than the minimum current, an ERROR 2 signal is created or calculated. In a like manner, comparator **612** determines the relationship of the actual current with the maximum set current and detector **622** creates or calculates an ERROR 3 signal when the actual current is above the maximum current set in line **456.** Turning again to the program in FIGURE 30, box **630** determines if there is an ERROR 2 signal. If there is an ERROR 2 signal, it means the current is near the minimum current as indicated by decision dock ~~832~~ 632. This produces a YES signal in line **634** to use the larger error as indicated by block **640.** This block indicates that the D/A converter **380** receives the larger of the ERROR 1 or ERROR 2 signals for adjusting inverter **382.** If there is no ERROR 2 signal, as determined by block **630**, block **650** is activated to determine if there is an ERROR 3 signal indicating a maximum current error. This would mean the signal is near the maximum current level as distinguished by decision block **652.** If the current is not near the minimum level nor the maximum level, a signal in line **654** bypasses program **600** and merely controls the inverter by the circuit shown in FIGURE 26. If the decision block **650** indicates that there is an ERROR 3 signal then block **660** is activated using the smaller of ERROR 3 and ERROR1 to control inverter **382.** Program **600** is one program for maintaining minimum and maximum current. However, the currents can merely be clipped at the values **454** and **456** to assure operation along sloped line **452.**